In [ ]:

```r
# Bibliotecas
if(!require(psych)){install.packages("psych")}
if(!require(FSA)){install.packages("FSA")}
if(!require(ggplot2)){install.packages("ggplot2")}
if(!require(car)){install.packages("car")}
if(!require(multcompView)){install.packages("multcompView")}
if(!require(lsmeans)){install.packages("lsmeans")}
if(!require(rcompanion)){install.packages("rcompanion")}

# 1. Carga de datos.
Data <- read.csv2("Datos_fixed_tarea_2_fix.csv", sep = ";", header = TRUE)
Data$Efectos <- as.factor(Data$Efectos)
Data$Objetos <- as.character(Data$Objetos)
Data$Objectos <- as.factor(Data$Objetos)
Data$Arquitectura <- as.factor(Data$Arquitectura)
Data$Resolucion <- as.factor(Data$Resolucion)
Data$Tiempo <- as.numeric(Data$Tiempo)

# 2. Verificación de la lectura de datos.
# Verificar que solo devuelva métricas para el tiempo.
# Si sale NA, factor no definido como tal.
library(psych)
headTail(Data)
str(Data)
summary(Data)

# 3. Gráficos simples de interacción
# Variable dependiente: Tiempo
# Variables independientes: Arquitectura y Objetos
interaction.plot(x.factor = as.numeric(Data$Objetos),
 trace.factor = Data$Arquitectura,
 response = Data$Tiempo,
 fun = mean,
 type = "b",
 col = c("black", "red", "green"),
 pch = c(19,17,15),
 fixed = TRUE,
 leg.bty = "o")
# Parece haber comportamiento exponencial.
# Pero el eje X dice cuantos objetos tenía la escena.
# Son potencias de 2.
# Se debe analizar si estamos forzando un comportamiento en alguno de los factores.
# APU se comporta mejor.

# Variable dependiente: Tiempo
# Variables independientes: Arquitectura y Resolucion
interaction.plot(x.factor = Data$Resolucion,
 trace.factor = Data$Arquitectura,
 response = Data$Tiempo,
 fun = mean,
 type = "b",
 col = c("black", "red", "green"),
 pch = c(19,17,15),
 fixed = TRUE,
 leg.bty = "o")

# Variable dependiente: Tiempo
# Variables independientes: Arquitectura y Efectos
interaction.plot(x.factor = Data$Efectos,
 trace.factor = Data$Arquitectura,
 response = Data$Tiempo,
 fun = mean,
 type = "b",
 col = c("black", "red", "green"),
 pch = c(19,17,15),
 fixed = TRUE,
 leg.bty = "o")
# Si hay interacción significativa entre objetos y efectos, los objetos
# impactan en cómo se comportan los efectos.

# 4. Evaluación de los supuestos.
# Función para graficos de los supuestos.
graficos_supuestos <- function(model) {
  par(mfrow = c(3, 1))
  x <- residuals(model)
```

```r
  library(rcompanion)
  plotNormalHistogram(x)
  plot(fitted(model), residuals(model))
  qqnorm(resid(model), main = "Normal Q-Q", xlab = "Theoretical Quantiles", ylab = "Standarized residuals")
  qqline(resid(model), col = "red", lwd = 2)
  par(mfrow = c(1, 1))
}

# Datos iniciales originales.
model <- lm(Tiempo ~ Objetos * Arquitectura * Efectos * Resolucion, data = Data)
graficos_supuestos(model)
leveneTest(Tiempo ~ Objetos * Arquitectura * Efectos * Resolucion, data = Data)

# 5. Tranformación por raíz cuadrada.
library(rcompanion)
T_sqrt <- sqrt(Data$Tiempo)
model <- lm(T_sqrt ~ Objetos * Arquitectura * Efectos * Resolucion, data = Data)
graficos_supuestos(model)
leveneTest(T_sqrt ~ Objetos * Arquitectura * Efectos * Resolucion, data = Data)
plot(model)

# 6. Anova
library(car)
Anova(model, type = "II")

# 7. Gráficos finales
# Arquitectura
Sum <- Summarize(T_sqrt ~ Arquitectura, data = Data, digits = 3)
Sum$se <- Sum$sd / sqrt(Sum$n)
Sum$se <- signif(Sum$se, digits = 3)

library(ggplot2)
pd <- position_dodge(.2)
ggplot(Sum,aes(x=Arquitectura, y=mean, color = Arquitectura)) + geom_errorbar(aes(ymin =
      mean - se,ymax = mean + se),width=.2,size=0.7, position=pd)+
      geom_point(aes(shape=Arquitectura), size=5, position=pd)+ theme_bw() +
      theme(plot.title = element_text(face="bold", hjust=0.5),
            axis.title = element_text(face="bold"),
            axis.text = element_text(face="bold"),
            plot.caption= element_text(hjust=0),
            legend.text = element_text(face="bold"),
            legend.title = element_text(face="bold"),
            legend.justification = c(1,0),
            legend.position="none") +
      ylab(expression("Promerdio de la raíz cuadrada del tiempo")) +
      ggtitle("Tiempo vs Arquitectura")

# Destransformando
Sum <- Summarize(T_sqrt ~ Arquitectura, data = Data, digits = 3)
Sum$mean <- Sum$mean^2
Sum$sd <- Sum$sd^2
Sum$se <- Sum$sd / sqrt(Sum$n)
Sum$se <- signif(Sum$se, digits = 3)

library(ggplot2)
pd <- position_dodge(.2)
ggplot(Sum,aes(x=Arquitectura, y=mean, color = Arquitectura)) + geom_errorbar(aes(ymin =
      mean - se,ymax = mean + se),width=.2,size=0.7, position=pd)+
      geom_point(aes(shape=Arquitectura), size=5, position=pd)+ theme_bw() +
      theme(plot.title = element_text(face="bold", hjust=0.5),
            axis.title = element_text(face="bold"),
            axis.text = element_text(face="bold"),
            plot.caption= element_text(hjust=0),
            legend.text = element_text(face="bold"),
            legend.title = element_text(face="bold"),
            legend.justification = c(1,0),
            legend.position="none") +
      ylab(expression("Tiempo promedio (s)")) +
      ggtitle("Tiempo vs Arquitectura")

# Arquitectura + Resolucion
Sum <- Summarize(T_sqrt ~ Arquitectura + Resolucion, data = Data, digits = 3)
Sum$se <- Sum$sd / sqrt(Sum$n)
Sum$se <- signif(Sum$se, digits = 3)

library(ggplot2)
```

```r
pd <- position_dodge(.2)
 ggplot(Sum,aes(x=Resolucion, y=mean, color = Arquitectura)) + geom_errorbar(aes(ymin =
      mean - se,ymax = mean + se),width=.2,size=0.7, position=pd)+
      geom_point(aes(shape=Arquitectura), size=5, position=pd)+ theme_bw() +
      theme(plot.title = element_text(face="bold", hjust=0.5),
            axis.title = element_text(face="bold"),
            axis.text = element_text(face="bold"),
            plot.caption= element_text(hjust=0),
            legend.text = element_text(face="bold"),
            legend.title = element_text(face="bold"),
            legend.justification = c(1,0)) +
      ylab(expression("Promerdio de la raíz cuadrada del tiempo")) +
      ggtitle("Tiempo vs Arquitectura")

# Destransformando
Sum <- Summarize(T_sqrt ~ Arquitectura + Resolucion, data = Data, digits = 3)
Sum$mean <- Sum$mean^2
Sum$sd <- Sum$sd^2
Sum$se <- Sum$sd / sqrt(Sum$n)
Sum$se <- signif(Sum$se, digits = 3)

library(ggplot2)
pd <- position_dodge(.2)
 ggplot(Sum,aes(x=Resolucion, y=mean, color = Arquitectura)) + geom_errorbar(aes(ymin =
      mean - se,ymax = mean + se),width=.2,size=0.7, position=pd)+
      geom_point(aes(shape=Arquitectura), size=5, position=pd)+ theme_bw() +
      theme(plot.title = element_text(face="bold", hjust=0.5),
            axis.title = element_text(face="bold"),
            axis.text = element_text(face="bold"),
            plot.caption= element_text(hjust=0),
            legend.text = element_text(face="bold"),
            legend.title = element_text(face="bold"),
            legend.justification = c(1,0)) +
      ylab(expression("Tiempo promedio (s)")) +
      ggtitle("Tiempo vs Arquitectura")

# Arquitectura y efectos
Sum <- Summarize(T_sqrt ~ Arquitectura + Efectos, data = Data, digits = 3)
Sum$se <- Sum$sd / sqrt(Sum$n)
Sum$se <- signif(Sum$se, digits = 3)
Sum$Efectos <- factor(Sum$Efectos,
                      levels(Sum$Efectos)[c(8,7,6,5,4,3,2,1)])

library(ggplot2)
pd <- position_dodge(.2)
ggplot(Sum,aes(x=Efectos, y=mean, color = Arquitectura)) + geom_errorbar(aes(ymin =
      mean - se,ymax = mean + se),width=.2,size=0.7, position=pd)+
      geom_point(aes(shape=Arquitectura), size=5, position=pd)+ theme_bw() +
      theme(plot.title = element_text(face="bold", hjust=0.5),
            axis.title = element_text(face="bold"),
            axis.text = element_text(face="bold"),
            plot.caption= element_text(hjust=0),
            legend.text = element_text(face="bold"),
            legend.title = element_text(face="bold"),
            legend.justification = c(1,0)) +
      ylab(expression("Promerdio de la raíz cuadrada del tiempo")) +
      ggtitle("Tiempo vs Arquitectura")

# Para salvar
# ggsave(plot = q, width = 14, height = 8, dpi = 300, filename = "arquitectura.png")
# Destransformando
Sum <- Summarize(T_sqrt ~ Arquitectura + Efectos, data = Data, digits = 3)
Sum$mean <- Sum$mean^2
Sum$sd <- Sum$sd^2
Sum$se <- Sum$sd / sqrt(Sum$n)
Sum$se <- signif(Sum$se, digits = 3)
Sum$Efectos <- factor(Sum$Efectos,
                      levels(Sum$Efectos)[c(8,7,6,5,4,3,2,1)])

library(ggplot2)
pd <- position_dodge(.2)
ggplot(Sum,aes(x=Efectos, y=mean, color = Arquitectura)) + geom_errorbar(aes(ymin =
      mean - se,ymax = mean + se),width=.2,size=0.7, position=pd)+
      geom_point(aes(shape=Arquitectura), size=5, position=pd)+ theme_bw() +
      theme(plot.title = element_text(face="bold", hjust=0.5),
            axis.title = element_text(face="bold"),
```

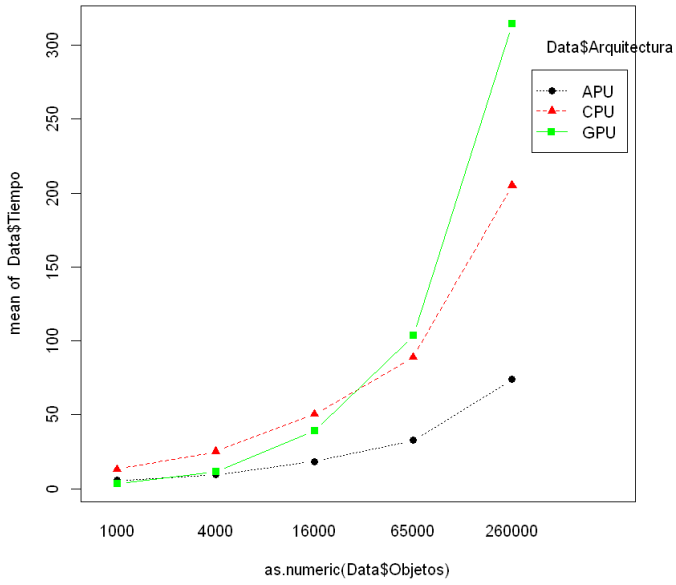
```
            axis.text = element_text(face="bold"),
            plot.caption= element_text(hjust=0),
            legend.text = element_text(face="bold"),
            legend.title = element_text(face="bold"),
            legend.justification = c(1,0)) +
      ylab(expression("Tiempo promedio (s)")) +
      ggtitle("Tiempo vs Arquitectura")

# Arquitectura y Objetos
Sum <- Summarize(T_sqrt ~ Arquitectura + Objetos, data = Data, digits = 3)
Sum$se <- Sum$sd / sqrt(Sum$n)
Sum$se <- signif(Sum$se, digits = 3)

library(ggplot2)
pd <- position_dodge(.2)
ggplot(Sum,aes(x=Objetos, y=mean, color = Arquitectura)) + geom_errorbar(aes(ymin =
      mean - se,ymax = mean + se),width=.2,size=0.7, position=pd)+
      geom_point(aes(shape=Arquitectura), size=5, position=pd)+ theme_bw() +
      theme(plot.title = element_text(face="bold", hjust=0.5),
            axis.title = element_text(face="bold"),
            axis.text = element_text(face="bold"),
            plot.caption= element_text(hjust=0),
            legend.text = element_text(face="bold"),
            legend.title = element_text(face="bold"),
            legend.justification = c(1,0)) +
      ylab(expression("Promerdio de la raíz cuadrada del tiempo")) +
      ggtitle("Tiempo vs Arquitectura")

# Destransformando es la misma vara

# 8. Pairwise t-test
pairwise.t.test(T_sqrt, Data$Arquitectura, p.adjust.method = "BH")
pairwise.t.test(T_sqrt, Data$Arquitectura : Data$Resolucion, p.adjust.method = "BH")
pairwise.t.test(T_sqrt, Data$Arquitectura : Data$Efectos, p.adjust.method = "BH")
# Se pueden hacer análisis de todas las interacciones que se quieran.

# 9. Conclusión.
# 1. En la totalidad de experimentos, el APU se comportó mejor.
# 2. Se identificó que para escenarios con pocos objetos, no hay diferencia. En escenarios donde la cantidad
# aumenta significativamente, entre más objetos hallan mejor el APU con respecto a las otras dos. En escenar
# no hay diferencia, pero en escenarios complejos si.
```

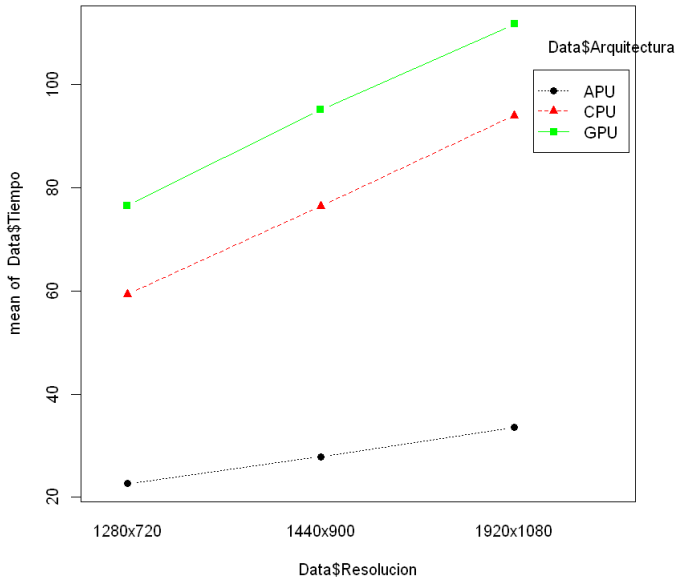
```
Loading required package: psych

Loading required package: FSA

## FSA v0.9.4. See citation('FSA') if used in publication.
## Run fishR() for related website and fishR('IFAR') for related book.


Attaching package: 'FSA'


The following object is masked from 'package:psych':

    headtail


Loading required package: ggplot2


Attaching package: 'ggplot2'


The following objects are masked from 'package:psych':

    %+%, alpha


Loading required package: car

Loading required package: carData

Registered S3 methods overwritten by 'car':
  method       from
  hist.boot    FSA
  confint.boot FSA


Attaching package: 'car'


The following object is masked from 'package:FSA':

    bootCase


The following object is masked from 'package:psych':

    logit


Loading required package: multcompView

Loading required package: lsmeans

Loading required package: emmeans

The 'lsmeans' package is now basically a front end for 'emmeans'.
Users are encouraged to switch the rest of the way.
See help('transition') for more information, including how to
convert old 'lsmeans' objects and scripts to work with 'emmeans'.

Loading required package: rcompanion


Attaching package: 'rcompanion'


The following object is masked from 'package:psych':

    phi
```

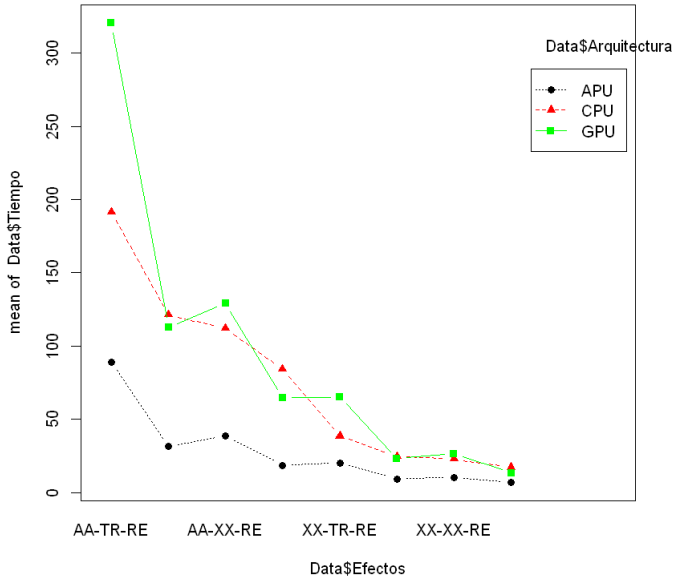
A data.frame: 9 × 6

	Tiempo	Objetos	Arquitectura	Efectos	Resolucion	Objectos
	<chr>	<chr>	<fct>	<fct>	<fct>	<fct>
1	6.53	16000	APU	XX-TR-XX	1280x720	16000
2	4.22	1000	APU	XX-TR-RE	1440x900	1000
3	6.13	1000	APU	AA-XX-RE	1280x720	1000
4	21.75	16000	APU	AA-TR-XX	1440x900	16000
...	...	NA	NA	NA	NA	NA
1797	11.75	16000	GPU	XX-TR-XX	1920x1080	16000
1798	31.93	4000	GPU	AA-TR-RE	1440x900	4000
1799	47.3	260000	GPU	XX-XX-XX	1440x900	260000
1800	5.44	1000	GPU	AA-XX-RE	1440x900	1000

```
'data.frame':   1800 obs. of  6 variables:
 $ Tiempo      : num  6.53 4.22 6.13 21.75 4.47 ...
 $ Objetos     : chr  "16000" "1000" "1000" "16000" ...
 $ Arquitectura: Factor w/ 3 levels "APU","CPU","GPU": 1 1 1 1 1 1 1 1 1 1 ...
 $ Efectos     : Factor w/ 8 levels "AA-TR-RE","AA-TR-XX",..: 6 5 3 2 7 7 2 8 1 2 ...
 $ Resolucion  : Factor w/ 3 levels "1280x720","1440x900",..: 1 2 1 2 1 1 2 1 2 3 ...
 $ Objectos    : Factor w/ 5 levels "1000","16000",..: 2 1 1 2 4 3 3 5 1 4 ...
    Tiempo           Objetos          Arquitectura     Efectos     
 Min.   :   0.880   Length:1800        APU:600      AA-TR-RE:225  
 1st Qu.:   7.315   Class :character   CPU:600      AA-TR-XX:225  
 Median :  20.130   Mode  :character   GPU:600      AA-XX-RE:225  
 Mean   :  66.326                                   AA-XX-XX:225  
 3rd Qu.:  64.073                                   XX-TR-RE:225  
 Max.   :1271.990                                   XX-TR-XX:225  
                                                    (Other) :450  

    Resolucion    Objectos   
 1280x720 :600   1000  :360  
 1440x900 :600   16000 :360  
 1920x1080:600   260000:360  
                 4000  :360  
                 65000 :360  
```

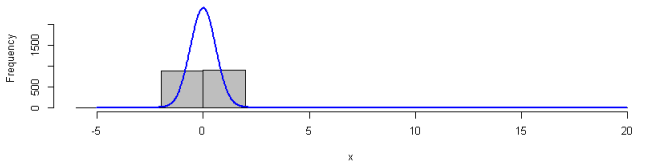


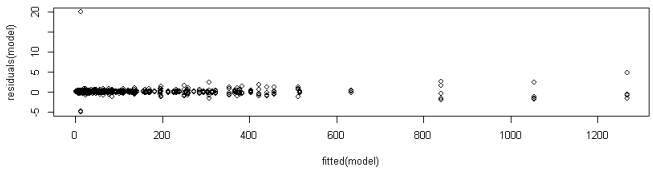


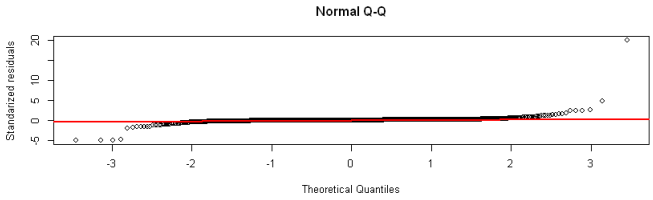


A anova: 2 × 3

	Df	F value	Pr(>F)
	<int>	<dbl>	<dbl>
group	359	1.298032	0.0006341896
	1440	NA	NA

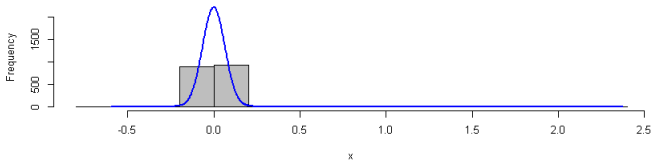


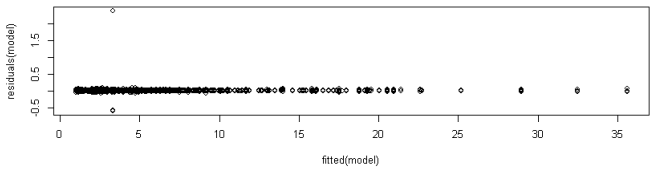


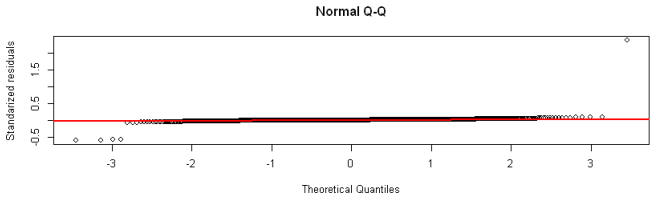


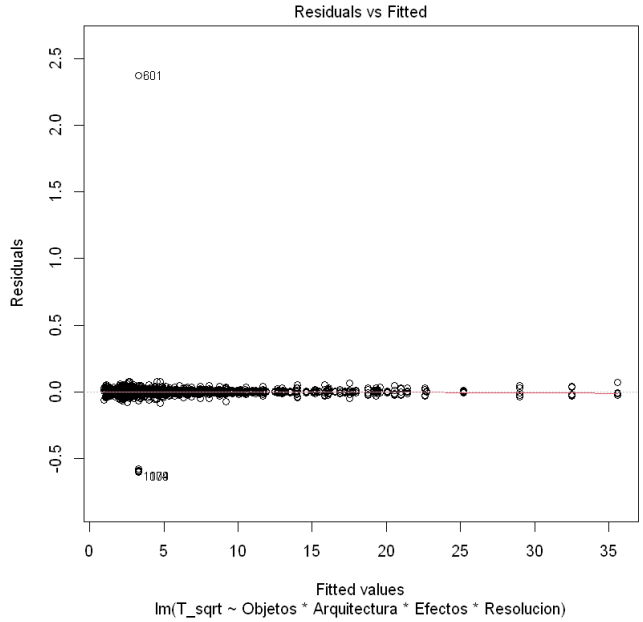
A anova: 2 × 3

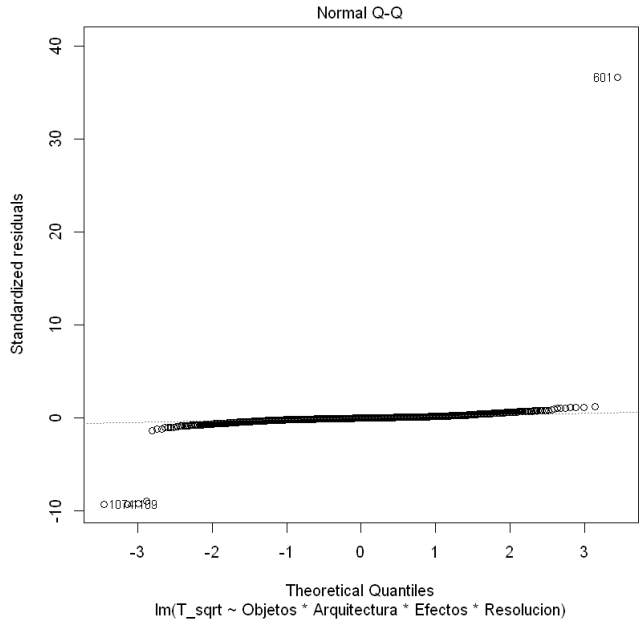
	Df	F value	Pr(>F)
	<int>	<dbl>	<dbl>
group	359	1.026171	0.3718046
	1440	NA	NA

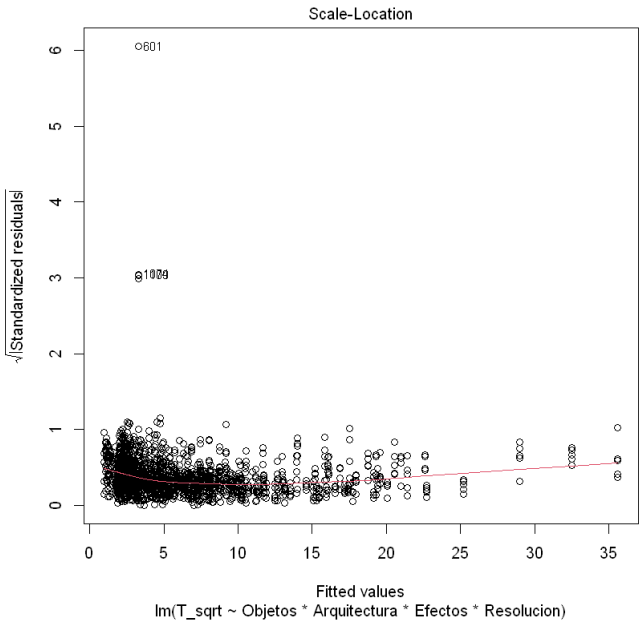







Residuals vs Fitted
Residuals
Fitted values
lm(T_sqrt ~ Objetos * Arquitectura * Efectos * Resolucion)

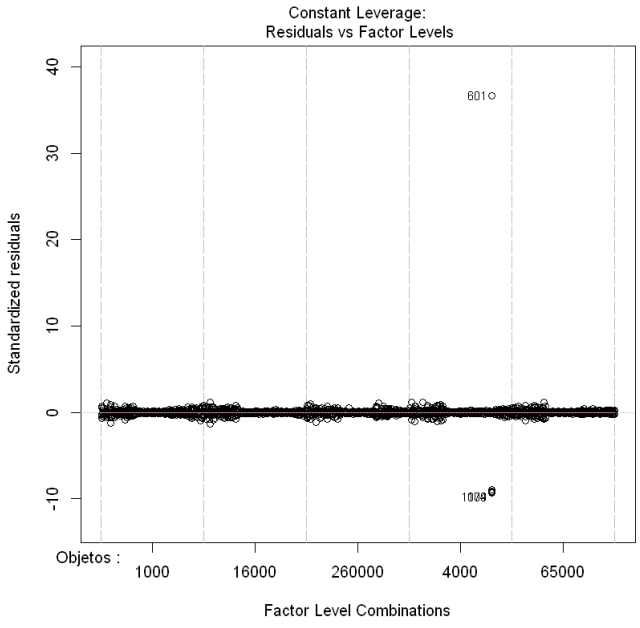

Normal Q-Q
Standardized residuals
Theoretical Quantiles
lm(T_sqrt ~ Objetos * Arquitectura * Efectos * Resolucion)

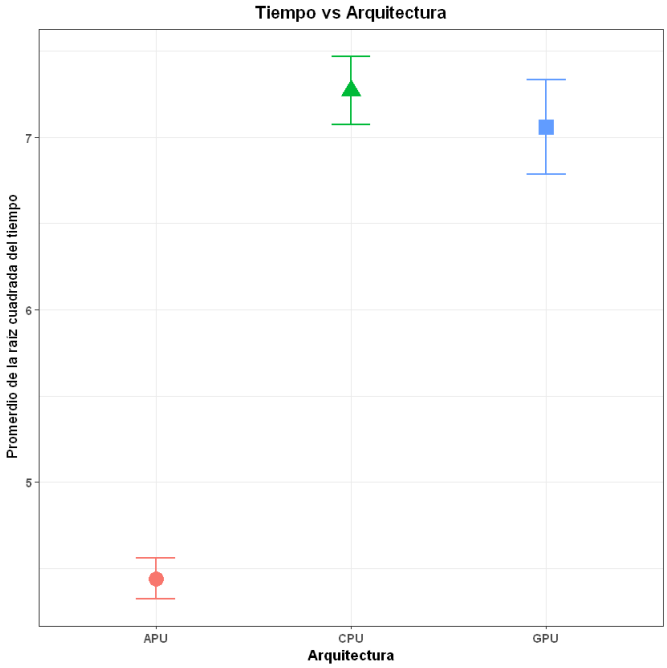

Scale-Location
√|Standardized residuals|
Fitted values
lm(T_sqrt ~ Objetos * Arquitectura * Efectos * Resolucion)

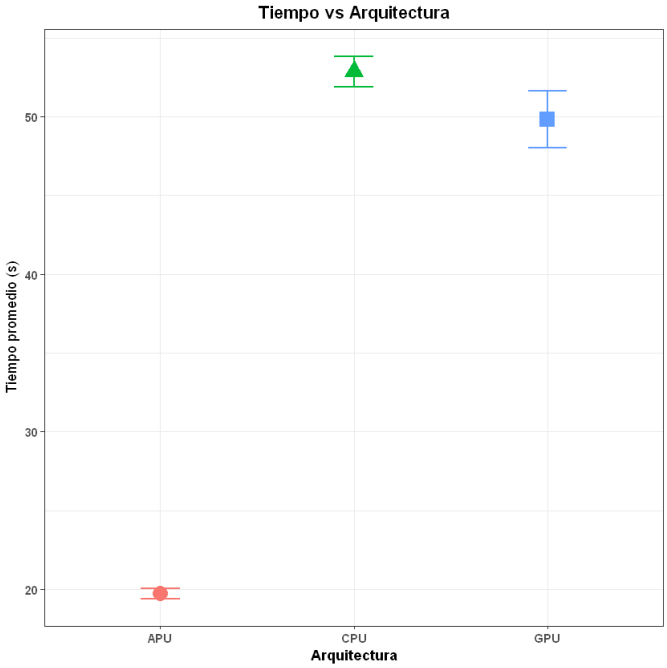
A anova: 16 × 4

	Sum Sq	Df	F value	Pr(>F)
	<dbl>	<dbl>	<dbl>	<dbl>
Objetos	21603.355587	4	1.030566e+06	0.000000e+00
Arquitectura	2980.900957	2	2.844016e+05	0.000000e+00
Efectos	12945.315384	7	3.528816e+05	0.000000e+00
Resolucion	463.209430	2	4.419385e+04	0.000000e+00
Objetos:Arquitectura	2944.326900	8	7.022803e+04	0.000000e+00
Objetos:Efectos	5538.622898	28	3.774489e+04	0.000000e+00
Arquitectura:Efectos	1284.558830	14	1.750816e+04	0.000000e+00
Objetos:Resolucion	150.970723	8	3.600951e+03	0.000000e+00
Arquitectura:Resolucion	41.517836	4	1.980565e+03	0.000000e+00
Efectos:Resolucion	111.457600	14	1.519134e+03	0.000000e+00
Objetos:Arquitectura:Efectos	750.722134	56	2.558030e+03	0.000000e+00
Objetos:Arquitectura:Resolucion	13.169713	16	1.570619e+02	1.497901e-301
Objetos:Efectos:Resolucion	57.364654	56	1.954658e+02	0.000000e+00
Arquitectura:Efectos:Resolucion	11.826925	28	8.059874e+01	6.509456e-271
Objetos:Arquitectura:Efectos:Resolucion	7.353165	112	1.252768e+01	2.586956e-145
Residuals	7.546543	1440	NA	NA

```
Warning message:
"Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
i Please use `linewidth` instead."
```




Tiempo vs Arquitectura
Promerdio de la raiz cuadrada del tiempo
7
6
5
APU
CPU
GPU
Arquitectura


Tiempo vs Arquitectura
Tiempo promedio (s)
50
40
30
20
APU
CPU
GPU
Arquitectura

In [ ]: